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(NASA-TM-X-51308) MEMORANDUM ON
MERCURY-REDSTONE BOOSTER DEVELOPMENT
FLIGHT (MR-BD) (NASA) 12 p

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By authority of [redacted]
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ti MEMORANDUM ON
MERCURY-REDSTONE BOOSTER DEVELOPMENT
FLIGHT (MR-BD) ~~(*)~~ (C) (**)

National ... Space Admin. Manned
Spacecraft Center, Houston, Tex.
6021604

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Patrick AFB, Fla. 26 Mar. 1961
(over)

PATRICK AIR FORCE BASE, FLORIDA

MARCH 26, 1961

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NASA - Space Task Group
Patrick Air Force Base, Florida
March 26, 1961

MEMORANDUM for Project Director

Subject: Mercury-Redstone booster development flight
(MR-BD)

Reference: Memorandum for Project Director Mar. 20, 1961
JBH/AJS:dpf

1. This memorandum presents a brief review of the Mercury-Redstone booster development flight (MR-BD) made on March 24, 1961. The flight utilized the MR-5 booster and a non-operating R&D type capsule. The flight was made to investigate corrections to the booster problems outlined in the reference memorandum.

2. Summary. - The MR-BD flight was highly successful. The countdown went smoothly with no holds. The item of primary concern, structural feedback to the control system, was corrected. Instrumentation compartment vibration was damped to an acceptable level. The thrust controller, H₂O₂ tank pressure regulator and velocity integrator all functioned normally. The roll-rate abort sensor, while disabled of its abort sensing function, was monitored and gave a reading of only 3 degrees per second maximum. Telemetry reception and recordings were excellent. The actual trajectory followed the planned trajectory very closely.

3. Capsule Description. - The capsule utilized for the MR-BD flight was designed and built by NASA-Langley Research Center for the Little Joe 1B flight test made in January, 1960 at Wallops Island, Virginia. It was ballasted and configured to simulate a Mercury production capsule (specifically, Capsule No. 7). A comparison of construction details between this capsule and the Mercury production capsule is shown in Figure 1. The escape system was standard Mercury configuration utilizing spent rocket motors ballasted to proper weight.

The overall weight and center of gravity of the launch configuration (adapter, capsule and escape assembly),

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as well as the weight and center of gravity of the separate components, closely approximated those of Capsule No. 7 at the time of Capsule No. 7 delivery to Cape Canaveral. These data are presented, for comparison, in the following Table:

	CAPSULE NO. 7				LITTLE JOE 1B			
	WEIGHT lb.	CENTER OF GRAVITY (Inches)			WEIGHT lb.	CENTER OF GRAVITY (Inches)		
		Z	Y	X		Z	Y	X
Escape Assembly	1,072.03	310.32	.04	-.04	1,075.75	312.00	-.04	.21
Capsule	2,827.55	120.34	.09	.06	2,837.70	120.42	.13	.06
Adapter	125.55	100.96	.30	-.47	125.55	102.07	.30	-.47
Launch Config.	4,016.13	170.49	.08	.02	4,039.04	170.67	.08	.09

The fairings which shield the explosive bolts on the main clamp ring were made in accordance with standard Mercury configuration.

A SOFAR bomb was attached to the interior of the capsule at the request of the Navy. The depth setting for detonation was 3,500 feet.

4. Launch Operations. - The launch procedures were arranged in a four-hour countdown which started at approximately 0830 EST. The countdown was for booster only, as the capsule was non-operational.

The countdown progressed smoothly with no major problems requiring holds. LOX loading occurred in the countdown at T-120 as compared to LOX loading during the normal Mercury-Redstone mission at T-390. A minor problem developed when 16 to 20 knots winds produced LOX sloshing during the LOX top-off operation. This sloshing caused false sensing indications and subsequent operation of the LOX topping computer. Consequently, the computer continued topping LOX. By lowering the bias in the topping circuit, the LOX level was decreased sufficiently to allow normal LOX topping.

This problem caused no hold in the count. Liftoff occurred at 1229:58 EST.

The Mercury egress rescue vehicle, an M113 armored personnel carrier, was parked 1,000 feet southwest of the booster to ascertain the visibility and sound level experienced by personnel manning the vehicle during the launch. Personnel manning the vehicle reported that no excessive noise was experienced and that the visibility from the carrier was excellent. Also, a truck was parked approximately 65 feet from the booster in the position that the mobile aerial tower will be for the manned Mercury launchings to determine any effects that the launching might have on the mobile tower. The truck sustained no apparent damage and was removed under its own power, indicating that the mobile tower would not be damaged during a normal operation when parked in this location.

The weather conditions at launch were good which permitted good photographic coverage. Surface winds were 16 to 20 knots, as previously noted. Upper winds were approximately 130 knots from due west.

5. Trajectory. - Range Zero was 1229:58 EST. Liftoff occurred 0.8 seconds later at 1229:58.8, and cutoff occurred at 141.7 seconds after liftoff.

The actual and planned trajectory parameters are as follows:

	ACTUAL	PLANNED
Earth-Fixed Velocity, ft/sec	6,560.0	6,471.3
Altitude, N. M.	98.8	99.2
Range, N. M.	267.1	274.5

The quality of the Azusa and FPS-16 radar tracking data for the MR-BD flight was considered much better than the data for the MR-1A and MR-2 flights. The transmission of IP 709 data to and from the Goddard computer was excellent and the plotboard data in the Mercury Control Center was as good as could be expected.

The Azusa and FPS-16 radar data were obtained for the following time intervals:

Time From Range Zero, Seconds	Tracking
0 to 11.3	Cape FPS-16
11.3 to 296.0	Azusa Mark II
296.0 to 503.0	GBI FPS-16

The quality of the FPS-16 skin track data after 296 seconds was considered as good as the beacon track data obtained on previous Mercury missions.

In general, there was hardly a plotting difference between the actual trajectory data computed from the above mentioned data sources and the nominal trajectory published in NASA Working Paper No. 178. A planned tilt arrest from range time of T+79.2 to T+87.2 had no effect on the desired cutoff conditions.

6. Results. - The reference memorandum discusses booster problems and planned corrections that led to the decision by the Marshall Space Flight Center that the MR-BD flight was required. The following is a discussion of the results obtained on the MR-BD flight concerning these problems and corrections.

(a) Vane vibration. - Incorporation of filters in the shaping network successfully eliminated this problem. Figure 3 shows a record segment during the latter part of powered flight (T+110 to T+125) where it can be seen that although some vibration at the second mode bending frequency was present, there was no vibration of the jet vanes. Also, it can be noted that the second mode bending frequency (8 cps) was not continuously sustained. The fact that it was not sustained is probably due to the fact that as no vane vibration occurred in response to this frequency, there is no vane feedback into the structure.

In an attempt to excite the second mode bending frequency at the time of high "q", a "controlled maneuver" was made during the MR-BD flight from a range time of T+79.2 to T+87.2. This maneuver consisted

of a temporary tilt arrest to build up a 2.3° angle of attack. The results of this maneuver were apparently negated due to upper winds of approximately 130 knots from due west. At any rate, this maneuver had little effect on the second mode bending frequency.

(b) Instrumentation Compartment Vibration. - High frequency vibration was still present in the area of the instrumentation compartment of the booster, though to a lesser degree. The telemetry data indicated a magnitude of $\pm 5.6g$ (using a $\pm 8g$ accelerometer measuring range) at T+70 as compared to a saturated reading (using a $\pm 6g$ accelerometer measuring range) on the MR-2 flight. It is, therefore, assumed that the fix of adding the 210 pounds of damping material to the internal surface of the instrument compartment structure damped this vibration to an acceptable level.

It is thought that the instrument compartment vibration is caused by aerodynamic excitation from the capsule-adaptor clamp ring fairings. On the MR-2 flight, a $\pm 6g$ accelerometer installed in the area of the clamp ring gave a saturated reading. On the MR-BD flight, the range of the accelerometer was extended to $\pm 12g$. The response was saturated from T+70 to T+90. Because of this saturation, the amount over $\pm 12g$ is not known.

(c) Thrust Controller. - The servo control valve which regulates H_2O_2 flow to the steam generator functioned normally as can be seen in Figure 4. This in turn gave optimum propellant flow which resulted in normal combustion chamber pressure as can be seen in Figure 5. After stabilization of pressure, a constant value of 317 PSIA was maintained throughout the flight. It is, therefore, assumed that the corrective action taken as stated in the reference memorandum regarding the thrust controller system was sufficient to overcome the difficulties that were encountered on the MR-2 flight.

(d) H_2O_2 Tank Pressure Regulator. - The pressure regulator of the H_2O_2 tank performed as expected. A reading of 585 PSIG was recorded from tank pressurization until liftoff of the booster at which time the pressure dropped to 525 PSIG and remained constant throughout the powered phase of the flight.

(e) Cutoff Arming Time. - The cutoff arming time and other mission sequence times, as outlined in the reference memorandum, were satisfactory for the MR-BD flight. Booster cutoff occurred at 141.7 seconds after liftoff as compared to a calculated value of 142.5 seconds.

(f) Roll-rate Abort Sensor. - The roll-rate abort sensor, while disabled of its abort sensing function, was monitored on a continuous telemeter channel for the MR-BD flight. The maximum rate recorded was 3 degrees per second, well below the value of over 8 degrees per second obtained on the MR-2 flight. (The peak value could not be established on the MR-2 flight as the measurement was on a commutated channel.)

It, therefore, appears that the high roll rates that were experienced with the MR-2 and MR-1A flights were probably due to the control system vane vibration which is now corrected. However, as outlined in the reference memorandum, the roll-rate abort sensor is not a necessary item in the Automatic Abort Sensing Ssystem so that its deletion on future Mercury-Redstone flights appears justifiable.

(g) H2O2 System Corrosion. - There was no evidence of H2O2 system corrosion on the booster during the pre-launch checkout period. No problems of any kind were experienced with the H2O2 system during the test.

(h) Man-hole LOX Leak. - There was no evidence of LOX leaks through the man-hole LOX cover during the prelaunch and launch periods. The increased bolt torques outlined in the reference memorandum appears to have corrected this problem.

(i) Velocity Integrator. - The velocity integrator allowed an error of +3 percent in cutoff velocity on the MR-1A flight. Since that time the integrator has been redesigned as outlined in the reference memorandum. On the MR-BD flight, the velocity integrator initiated the cutoff signal after 141.7 seconds of flight time. This was 0.8 seconds prior to the predicted cutoff time. The velocity at cutoff was 88.7 feet per second greater than the planned velocity, an error of approximately 1 percent. This performance is considered satisfactory.

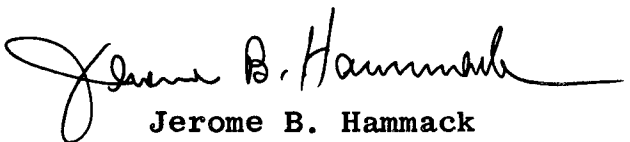
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A report of SOFAR bomb detonation was received after the flight. Details of location and time are not known at this writing.

7. Conclusion. -

(a) All booster corrections were satisfactory.


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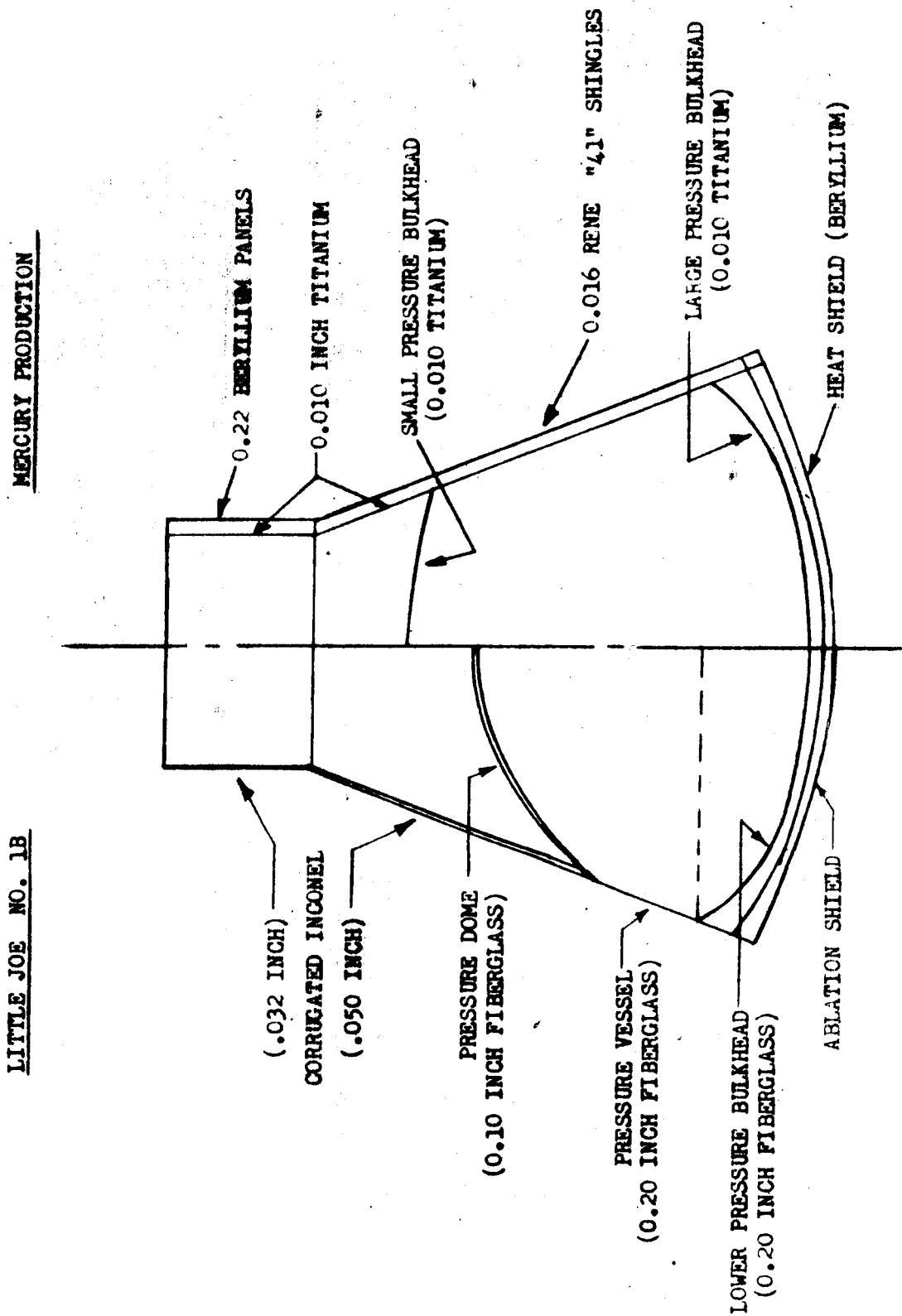
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FIGURE NO.1.- COMPARISON OF CONSTRUCTION OF A LITTLE JOE AND A MERCURY PRODUCTION CAPSULE.

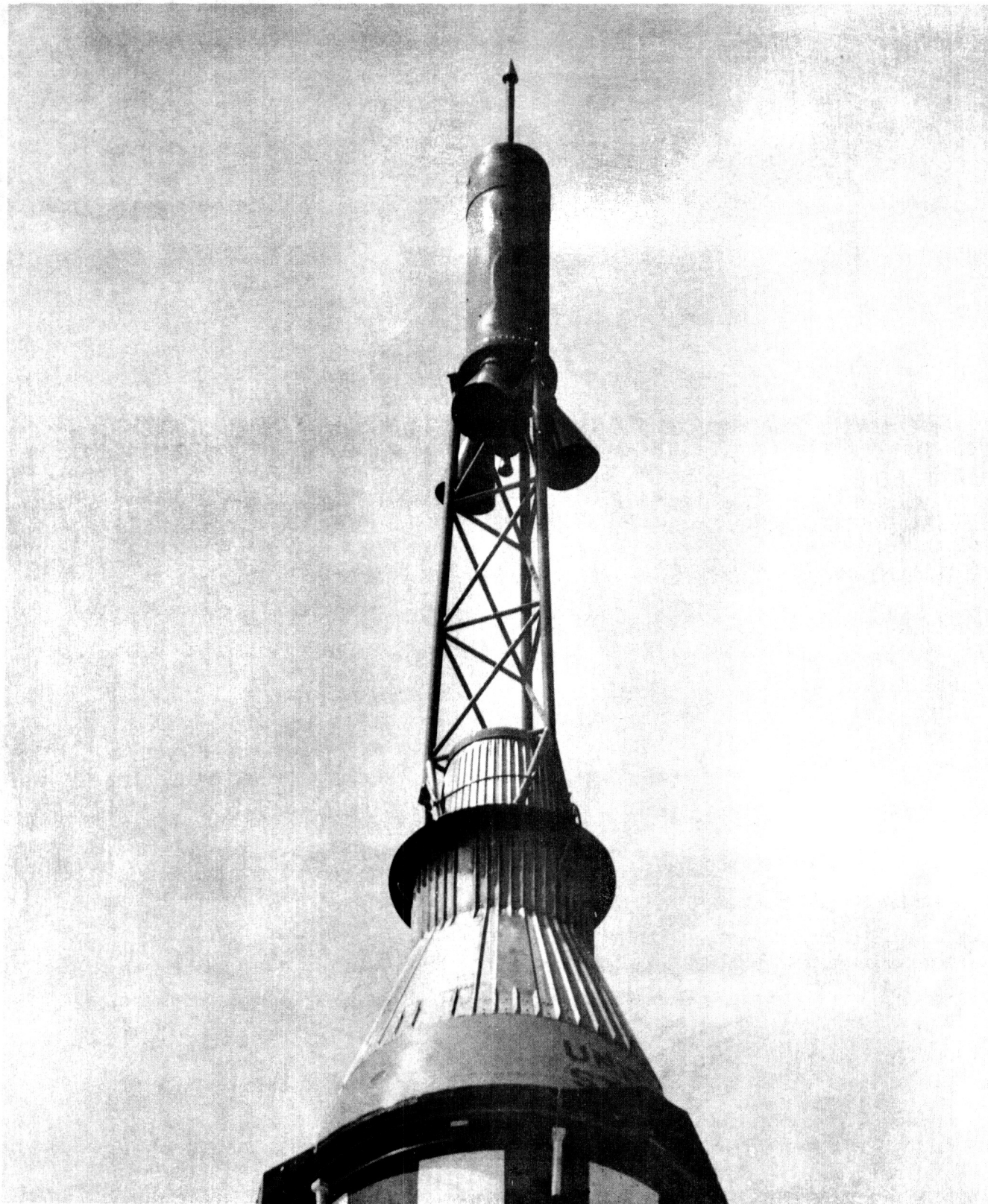


FIGURE NO. 2 - VIEW OF CAPSULE MOUNTED ON BOOSTER

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Jet Vane No. 2

Second Order Bending Excitation

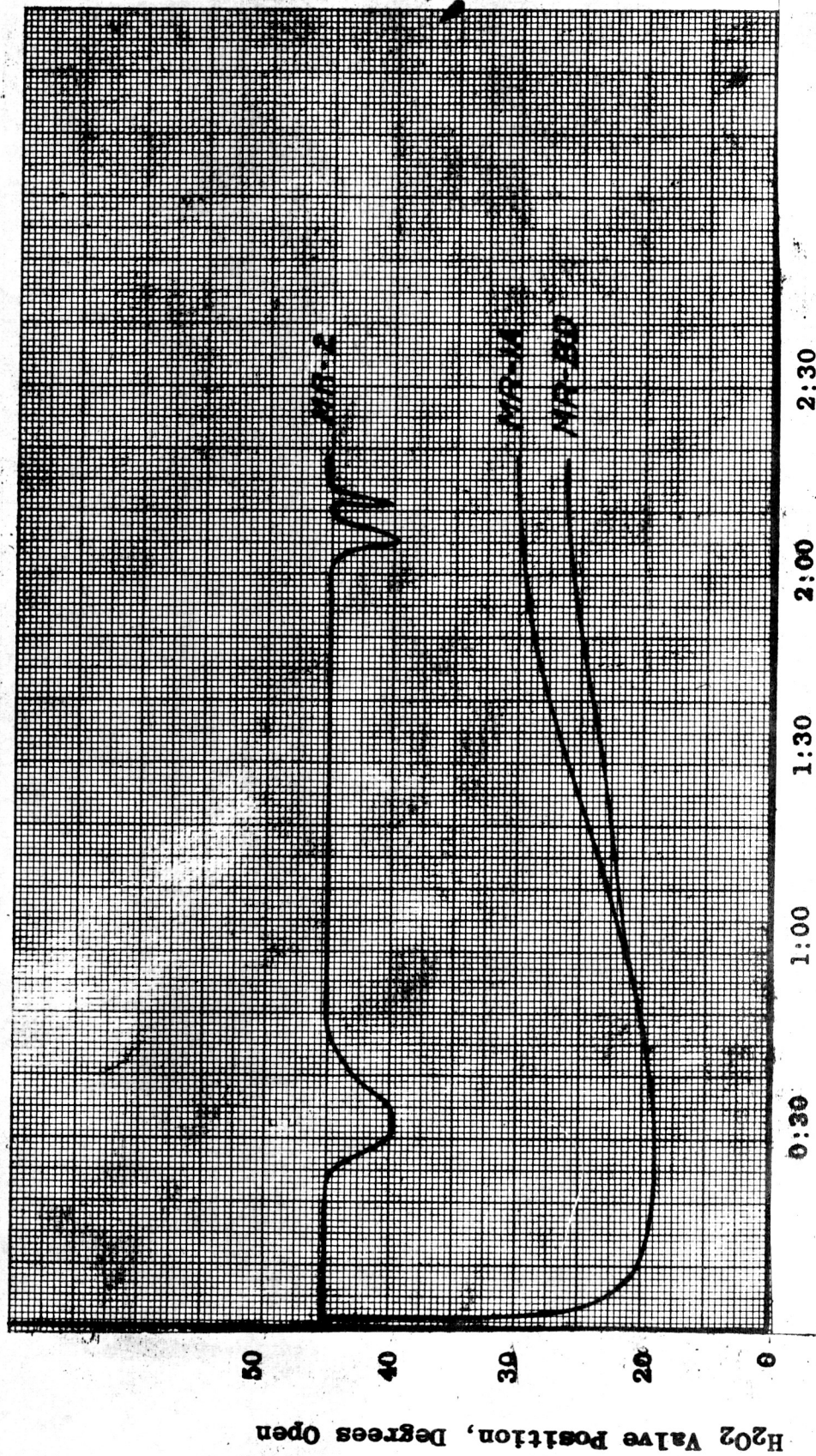
Jet Vane No. 1

T + 110 Sec

T + 125 Sec

FIGURE NO. 3.- TYPICAL RECORD SHOWING RESPONSE OF JET VANES TO SECOND ORDER BENDING EXCITATION.

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Range Time (Minutes, Seconds)

FIGURE NO. 4. - HYDROGEN PEROXIDE VALVE BLADE POSITION VERSUS TIME



FIGURE NO. 5. - THRUST CHAMBER PRESSURE FOR MR-BD FLIGHT